National Air Quality Forecasting Capability: performance, recent updates and plans

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5 EPA

2010 National Air Quality Conferences, Raleigh, North Carolina *March 17, 2010*

Outline

Background on NAQFC

Progress in 2009/2010

- *Operational products*
- *Experimental testing/products*
- *Developmental testing*

Coordination with Partners

Looking Ahead

National Air Quality Forecast Capability

Current and Planned Capabilities (2/10)

- Improving the basis for AQ alerts
- Providing AQ information for people at risk

Prediction Capabilities:

- **Operations:**

  Ozone implemented over CONUS (9/07)

  Smoke implemented over CONUS (3/07), AK (9/09) and HI (2/10)

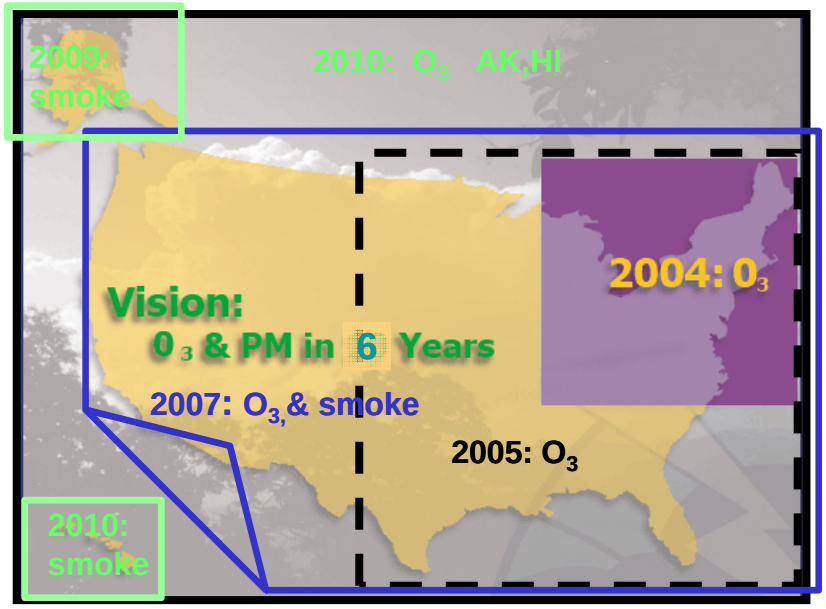
- **Experimental testing/products:**

  Ozone upgrades

- **Developmental testing:**

  Ozone over AK and HI

  Components for particulate matter (PM) forecasts



National Air Quality Forecast Capability
End-to-End Operational Capability

Model Components: Linked numerical prediction system

Operationally integrated on NCEP's supercomputer

- *NCEP mesoscale NWP: WRF-NMM*
- *NOAA/EPA community model for AQ: CMAQ*

Observational Input:

- *NWS weather observations; NESDIS fire locations*
- *EPA emissions inventory*

Gridded forecast guidance products

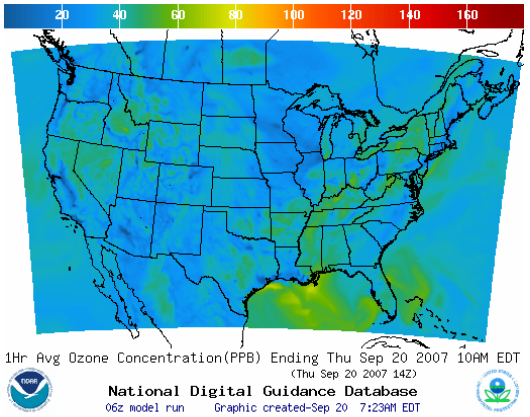
- *On NWS servers: www.weather.gov/aq and ftp-servers*
- *On EPA servers*
- *Updated 2x daily*

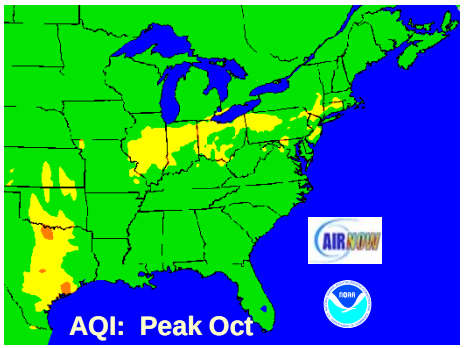
Verification basis, near-real time:

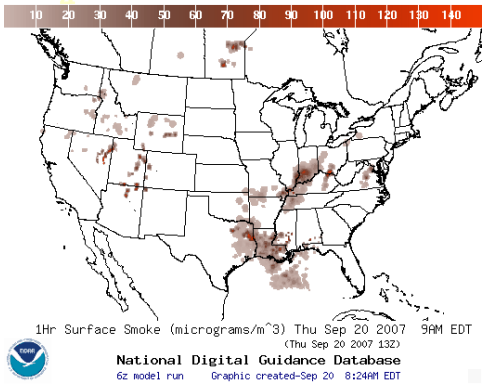
- *Ground-level AIRNow observations*
- *Satellite smoke observations*

Customer outreach/feedback

- *State & Local AQ forecasters coordinated with EPA*
- *Public and Private Sector AQ constituents*







Progress in 2009/2010

Ozone Upgrades: Operations (9/18/07) over Coast-to-Coast (CONUS) domain

- *Operations: CONUS (updated emissions);* ***new 1, 8-hour daily maximum products***
- *Experimental Testing: CB-05 chemical mechanism*
- *Developmental testing: developing prototypes for AK, HI*

Smoke: Operations (3/1/07) over CONUS

- *Operations: CONUS Dec 2008 upgrades.* ***AK (9/29/09), HI (2/23/10) smoke implemented into operations***
- *Developmental testing: Improvements to verification*

Aerosols: Developmental testing providing comprehensive dataset for diagnostic evaluations. (CONUS)

- *CMAQ (aerosol option), testing CB05 chemical mechanism*
  - Qualitative; summertime underprediction consistent with missing source inputs
- *Dust and smoke inputs: testing dust contributions to PM2.5 from global sources*
  - Preliminary tests combining dust with CMAQ-aerosol
  - Case studies combining smoke inputs with CMAQ-aerosol
- *Testing prediction of dust from CONUS sources*
- *R&D efforts continuing in chemical data assimilation, real-time emissions sources, advanced chemical mechanisms*

Updates in 2009
Operational Products

NAM update (December, 2008)

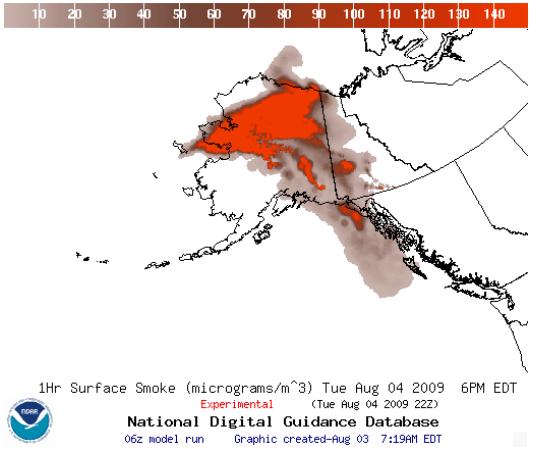
- **Model Parameterizations:** PBL/turbulence schemes and vertical diffusion applied to separate water species, absorption coefficients for water and ice doubled in radiation scheme, changes to land-surface physics under snow coverage
- **Data assimilation:** Upgraded GSI with a new version of radiative transfer, more satellite and aircraft obs
- **Initialization:** Background for the first analysis comes from the global system (GDAS)

Ozone Predictions: Emissions Updates (May, 2009)

- **Point, area and mobile source emissions: updated based on NEI (2005) and projected for the current year.**
  - *EPA Office of Transportation and Air Quality on-road emissions estimates*
  - *EGU sources: 2007 CEM data projected for 2009.*
- **Biogenic sources: updated with BEIS 3.13**

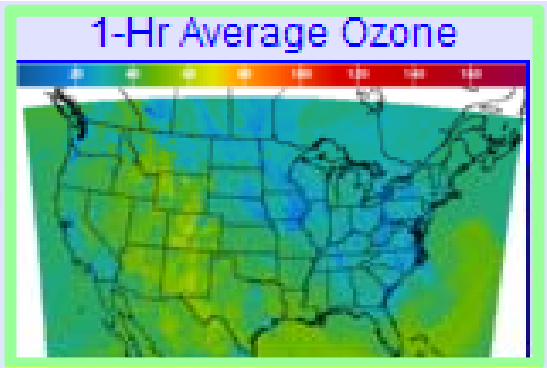
Smoke:

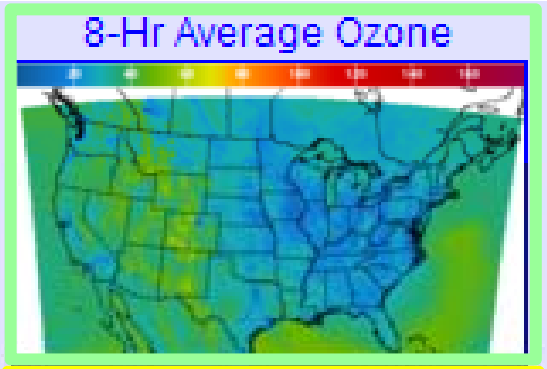
- **Alaska:** operational implementation on Sept 29, 2009
- **Hawaii:** operational implementation on Feb 23, 2010

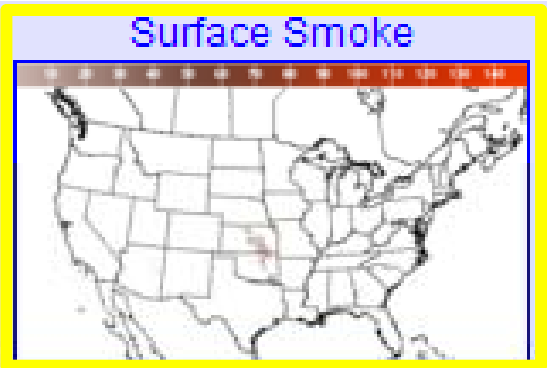


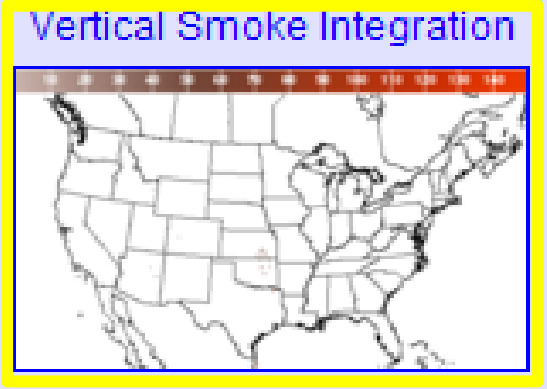
Operational AQ forecast guidance

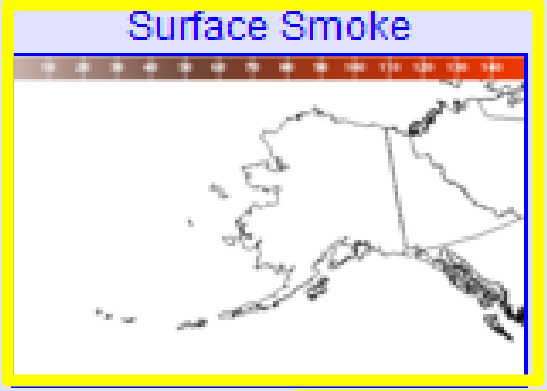
www.weather.gov/aq

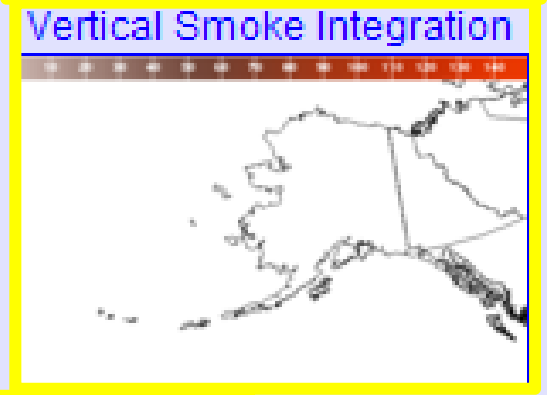


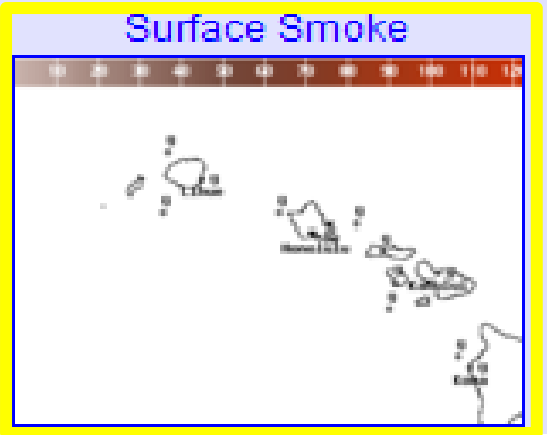


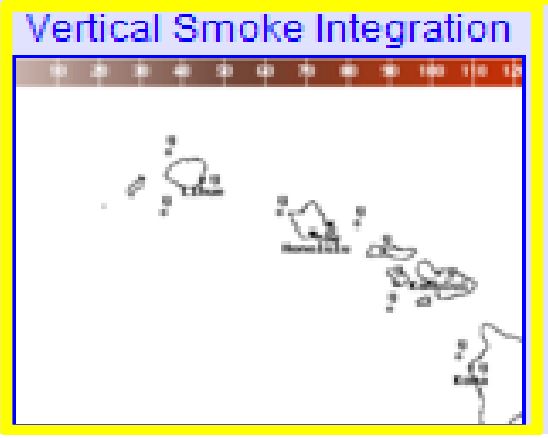










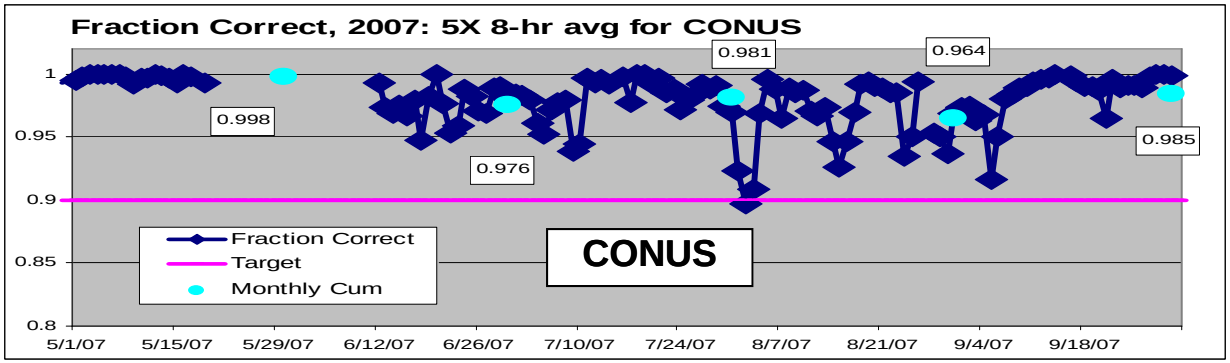


Ozone: CONUS

Smoke: CONUS, AK and HI

Progress from 2007 to 2009:

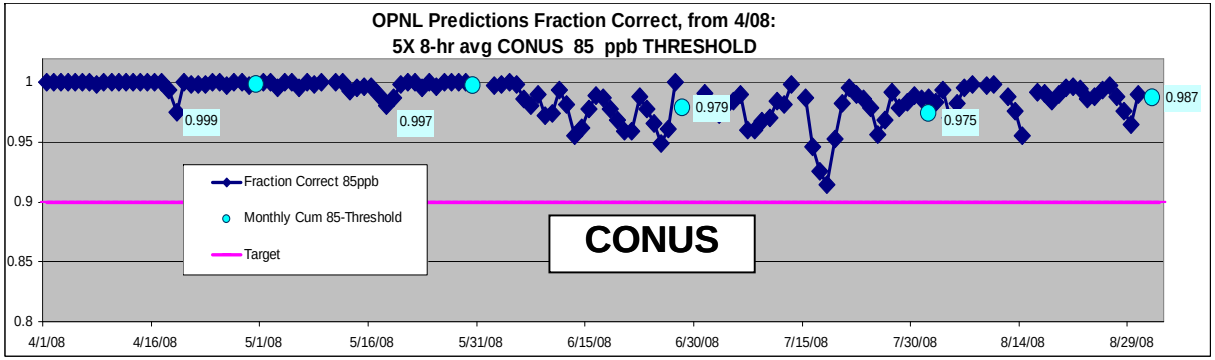
CONUS O_3 Prediction Summary Verification



2007 **Experimental**

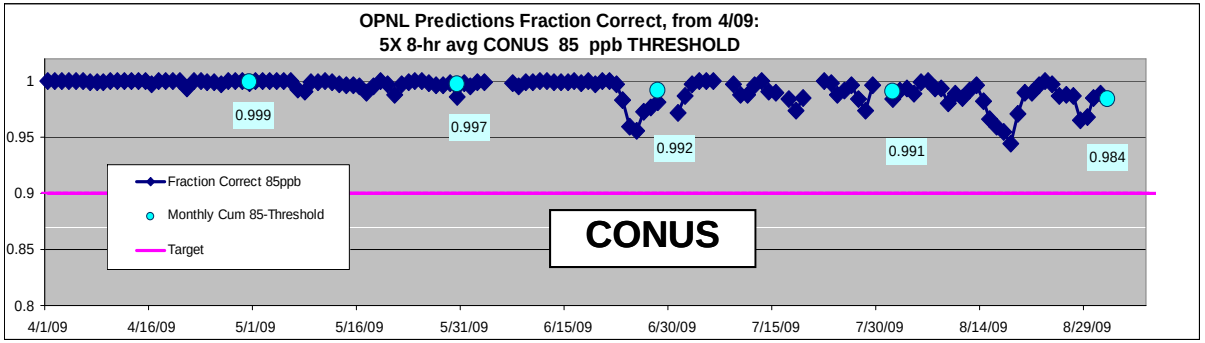
Contiguous US (CONUS)

Implemented 9/07 to replace Eastern US config in operations



2008 **Operational**

CONUS, wrt 85ppb Threshold



2009 **Operational**

CONUS, wrt 85ppb Threshold

Real-time Testing, Summer 2009:
Experimental Testing

Experimental Predictions

Publicly available, real-time

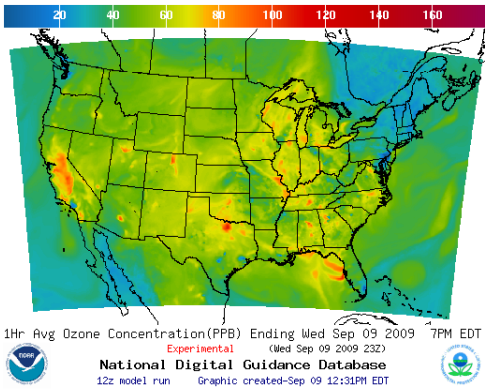
Ozone:

- *CMAQ with advanced gas-phase chemical mechanism CB05*
  - more Volatile Organic Compound (VOC) reactions
  - challenge: more O_3 with CB05
  - regional implications: CA, NE US

Smoke:

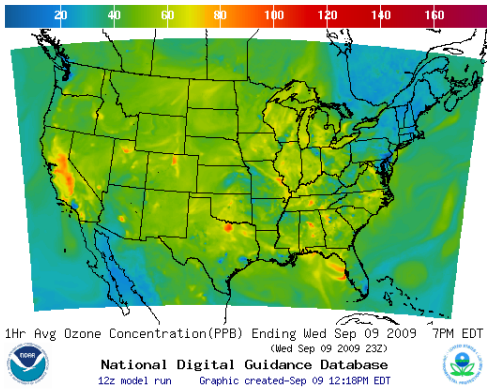
- *Testing over AK and HI domains*
  - new GOES-W smoke verification
  - AK: active summer 2009 fire season; over 2.9 M acres burned

Experimental

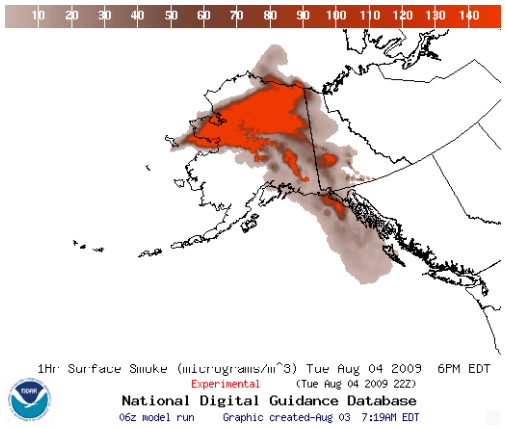


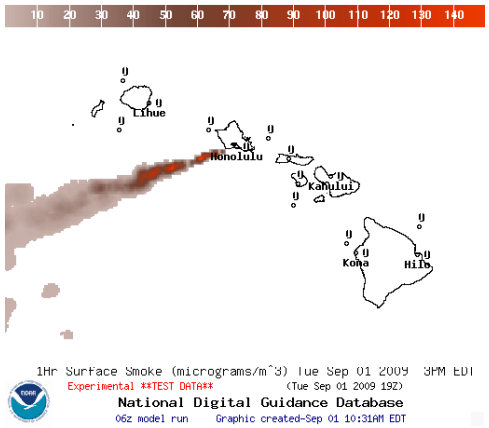
weather.gov/aq-expr

Operational



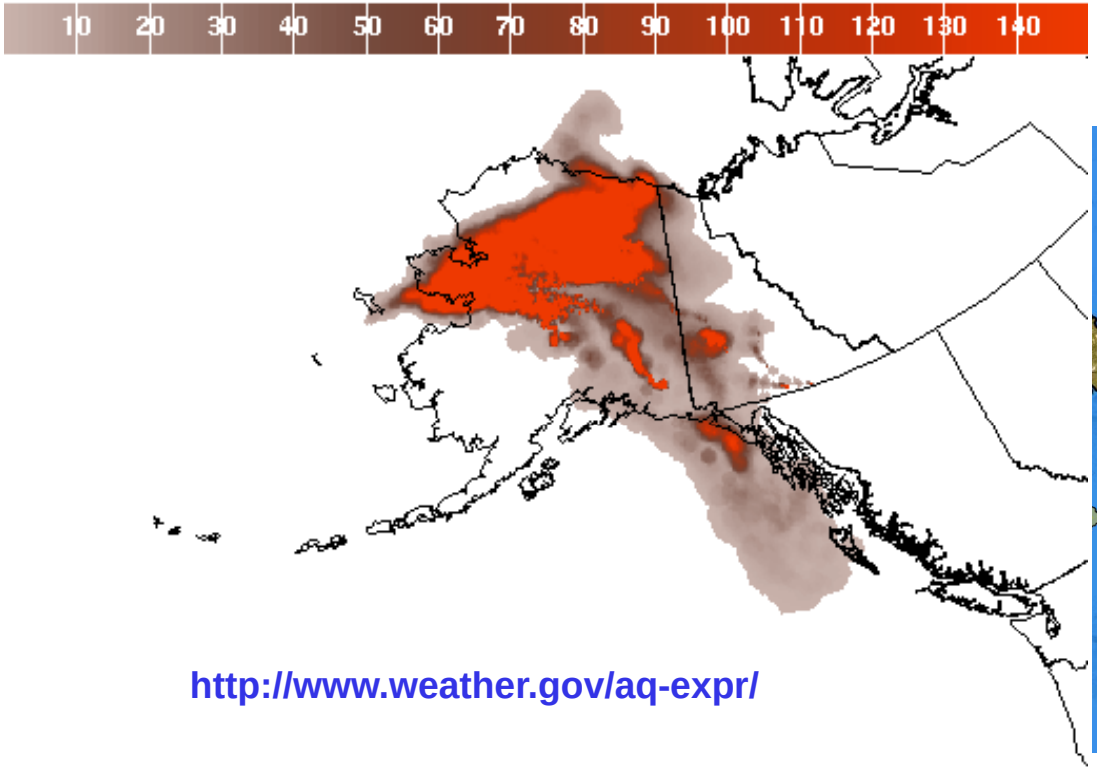
weather.gov/aq



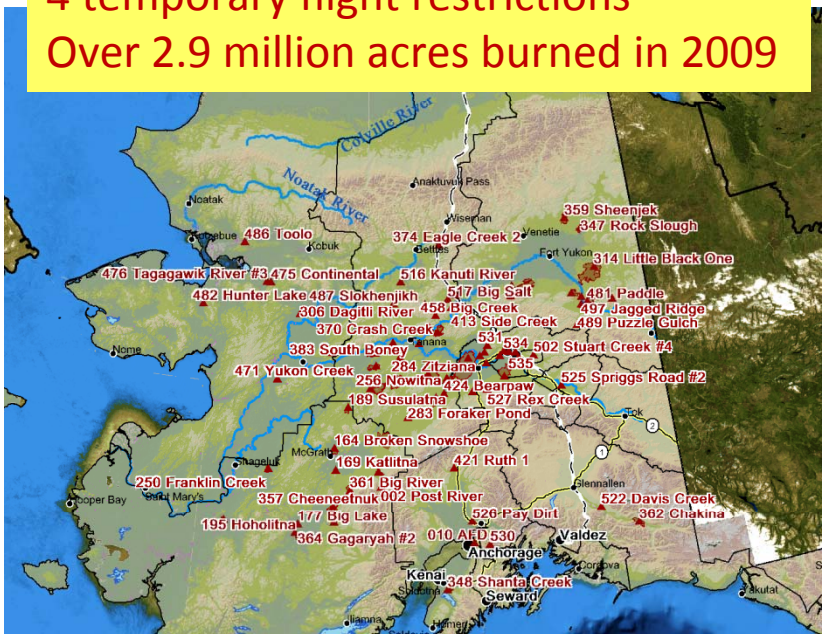


Both now operational

Smoke from wildfires in Alaska

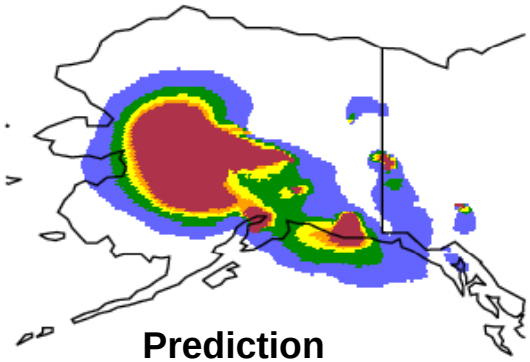


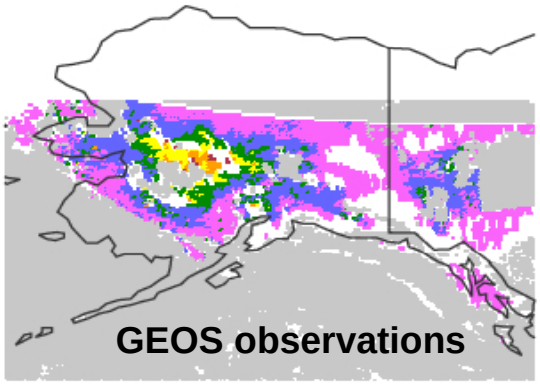
86 active wildfires on **August 4, 2009**
4 temporary flight restrictions
Over 2.9 million acres burned in 2009



- Large Alaskan fires began in early July 2009
- Driest July ever recorded in Fairbanks (only 0.06” since July 1, normally the second wettest month of the year) and second warmest July ever (avg 66.5 deg).

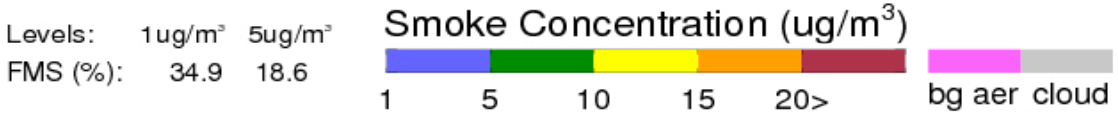
Verification of Alaska smoke predictions





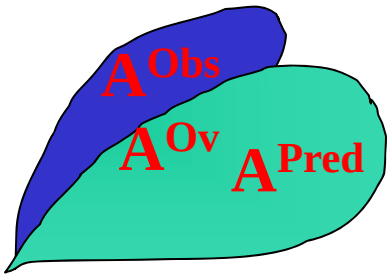
Example
7/13/09, 17-18Z

FMS = 35%,
for column-averaged
smoke > 1 ug/m³

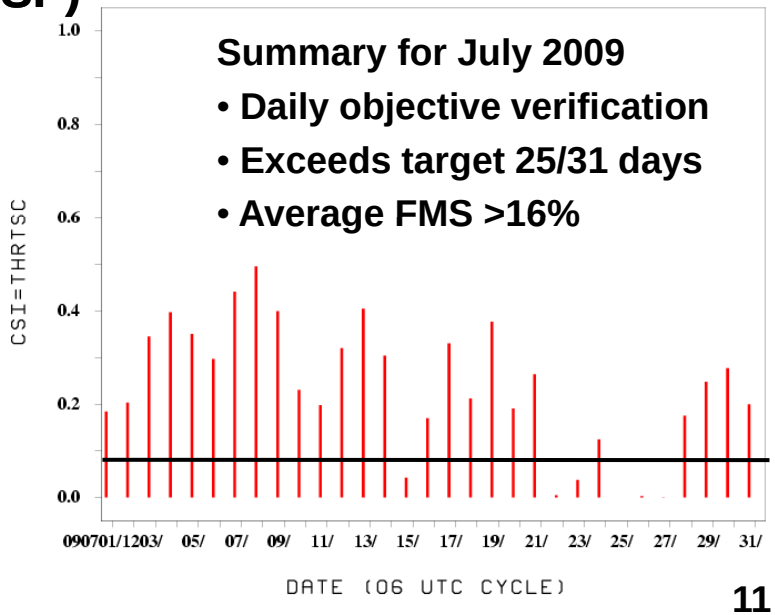


First routine, real-time objective verification for wildfire smoke in Alaska

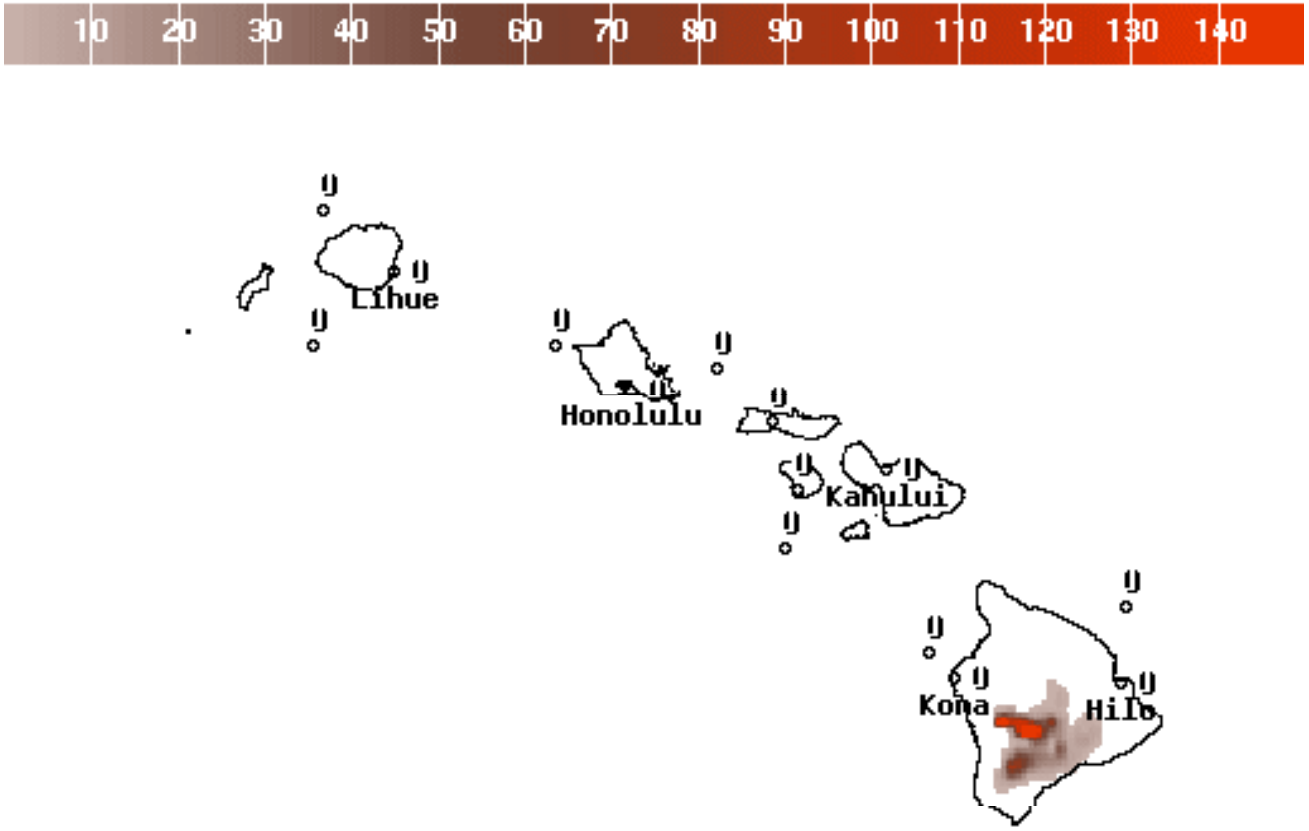
- **Uses new GOES Aerosol Smoke Product (GASP)**
  - *Smoke from identified fires only*
  - *Filtered for interference from clouds, surface reflectance, solar angle, other aerosol*
- **"Footprint" comparison with Figure-of-merit statistics for concentration of (1 µg/m³):**



$$\frac{\text{(Area Pred} \cap \text{Area Obs)}}{\text{(Area Pred. U Area Obs)}}$$

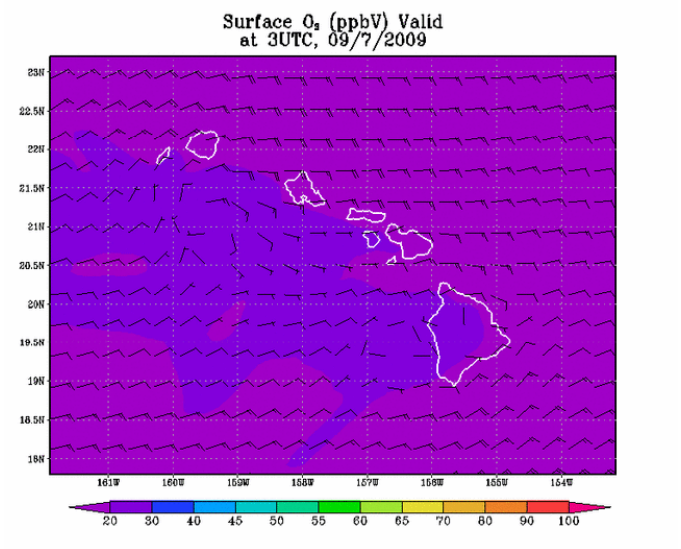


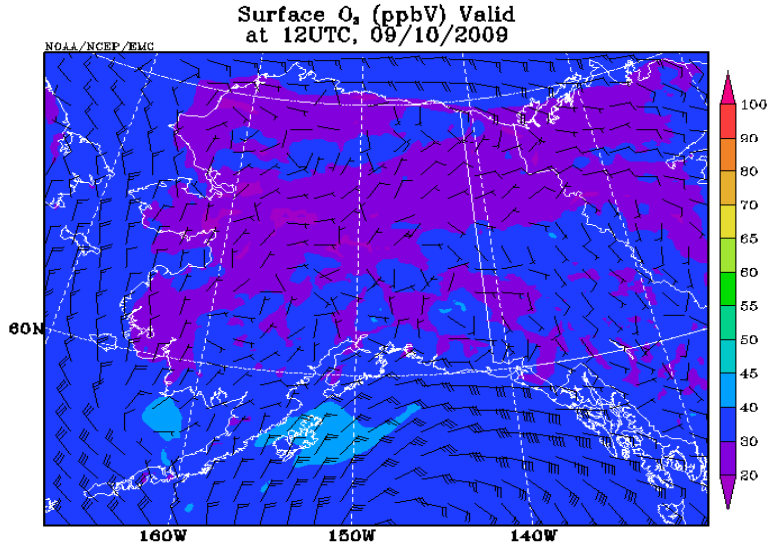
Testing of HI smoke predictions



Developmental predictions, Summer 2009

HI and AK ozone (from Aug 2009) using CMAQ with CB05 (gases)



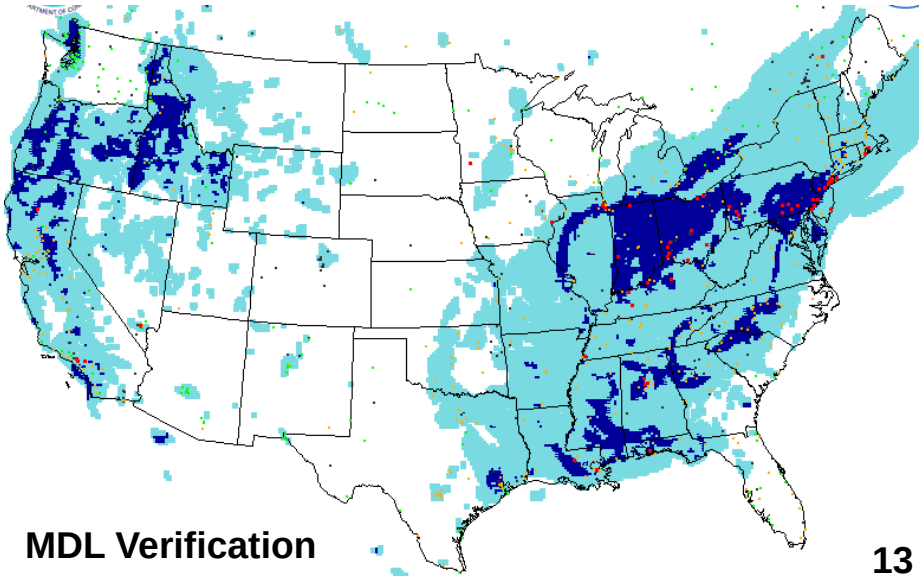


Focus group access only, real-time as resources permit

Aerosols over CONUS

From NEI sources only

- CMAQ: CB05 gases, AERO-4 aerosols
- sea salt emissions and reactions

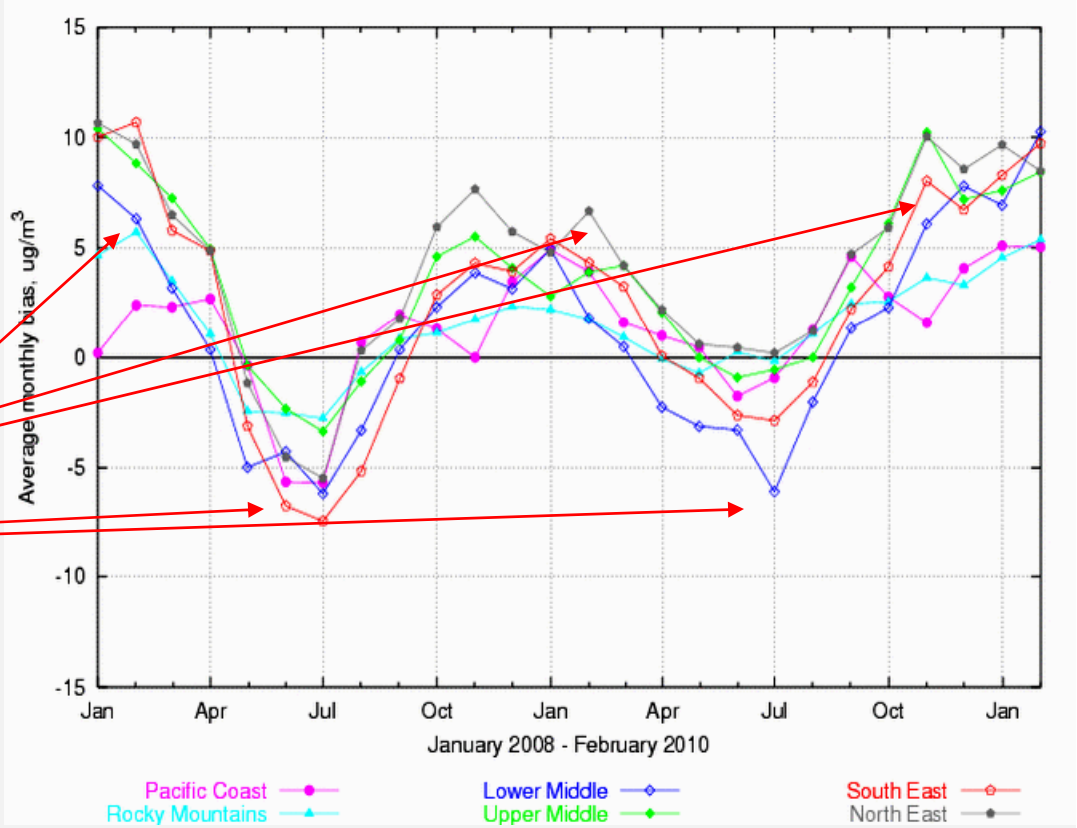


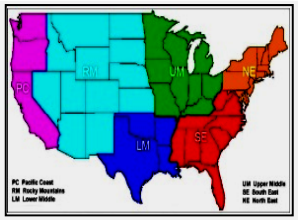
MDL Verification

Quantitative PM performance

Forecast challenges

- *Aerosol simulation using emission inventories:*
  - Show seasonal bias--winter, overprediction; summer, underprediction
- *Intermittent sources*
- *Chemical boundary conditions/trans-boundary inputs*





Partnering with AQ Forecasters

Focus group, State/local AQ forecasters:

- **Participate in real-time developmental testing of new capabilities, e.g. aerosol predictions**
- **Provide feedback on reliability, utility of test products**
- **Local episodes/case studies emphasis**
- **Regular meetings; working together with EPA's AIRNow and NOAA**

- ***Feedback is essential for refining/improving coordination***

http://www.epa.gov/airnow/airaware/

Feedback Examples

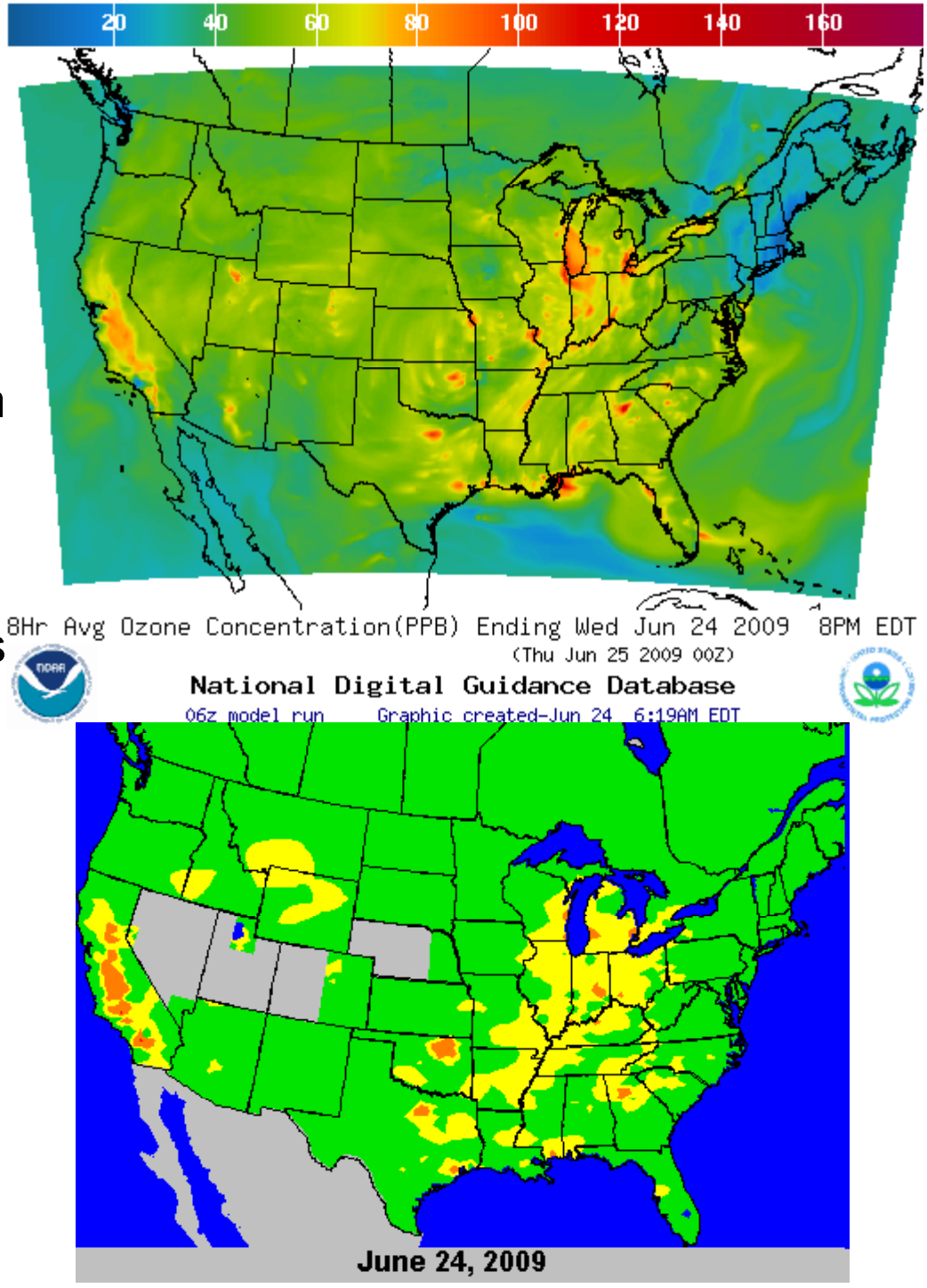
From Brian Lambeth, Texas CEQ:

Daily comparison of late-day predictions with AIRNow summary.

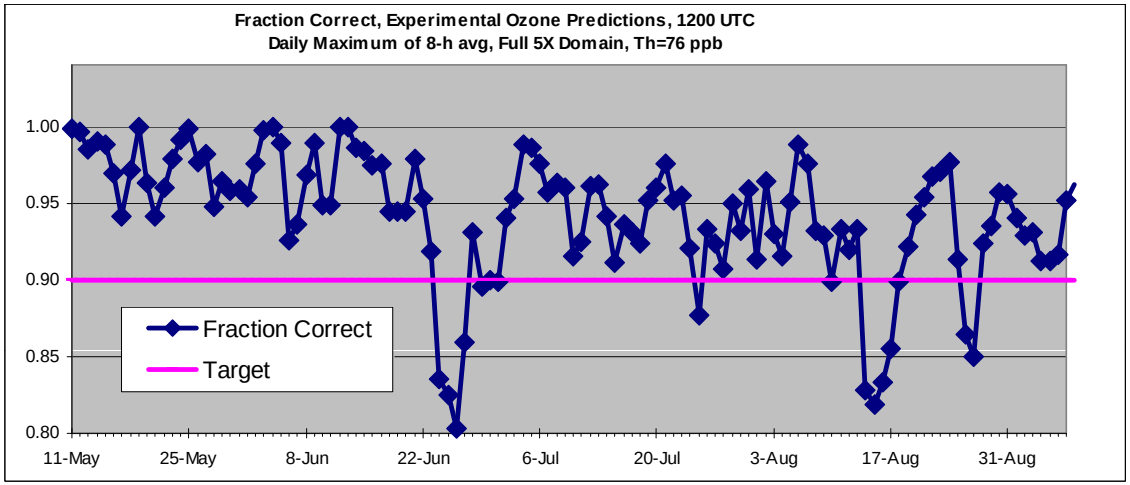
"… tendency for the model to over-predict the highest ozone levels more often than not…[e.g] Atlanta."

From Bill Murphey, Georgia EPD:

Mean overprediction of daily 8-h maximum ozone over Atlanta is 6.9 ppb and correlation is 0.7 for summer 2009

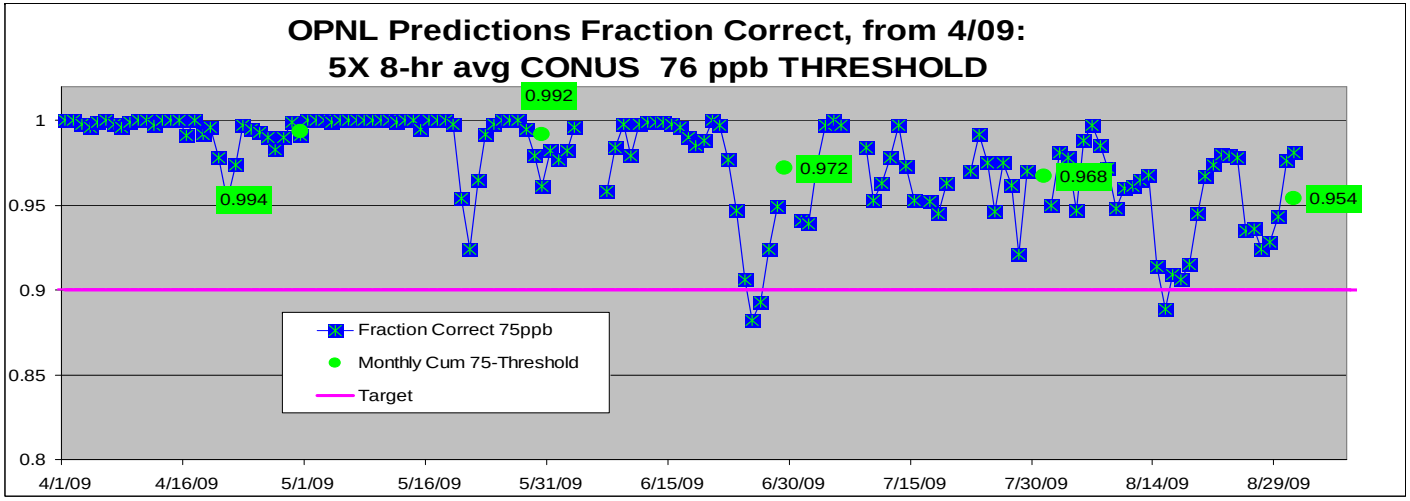


Real-time Testing, Summer 2009:
Experimental vs Operational O_3 at 76 ppb



Experimental

CB05-based



Operational

CBIV-based

Experimental vs. Operational, 76 ppb: FC decreases in experimental predictions

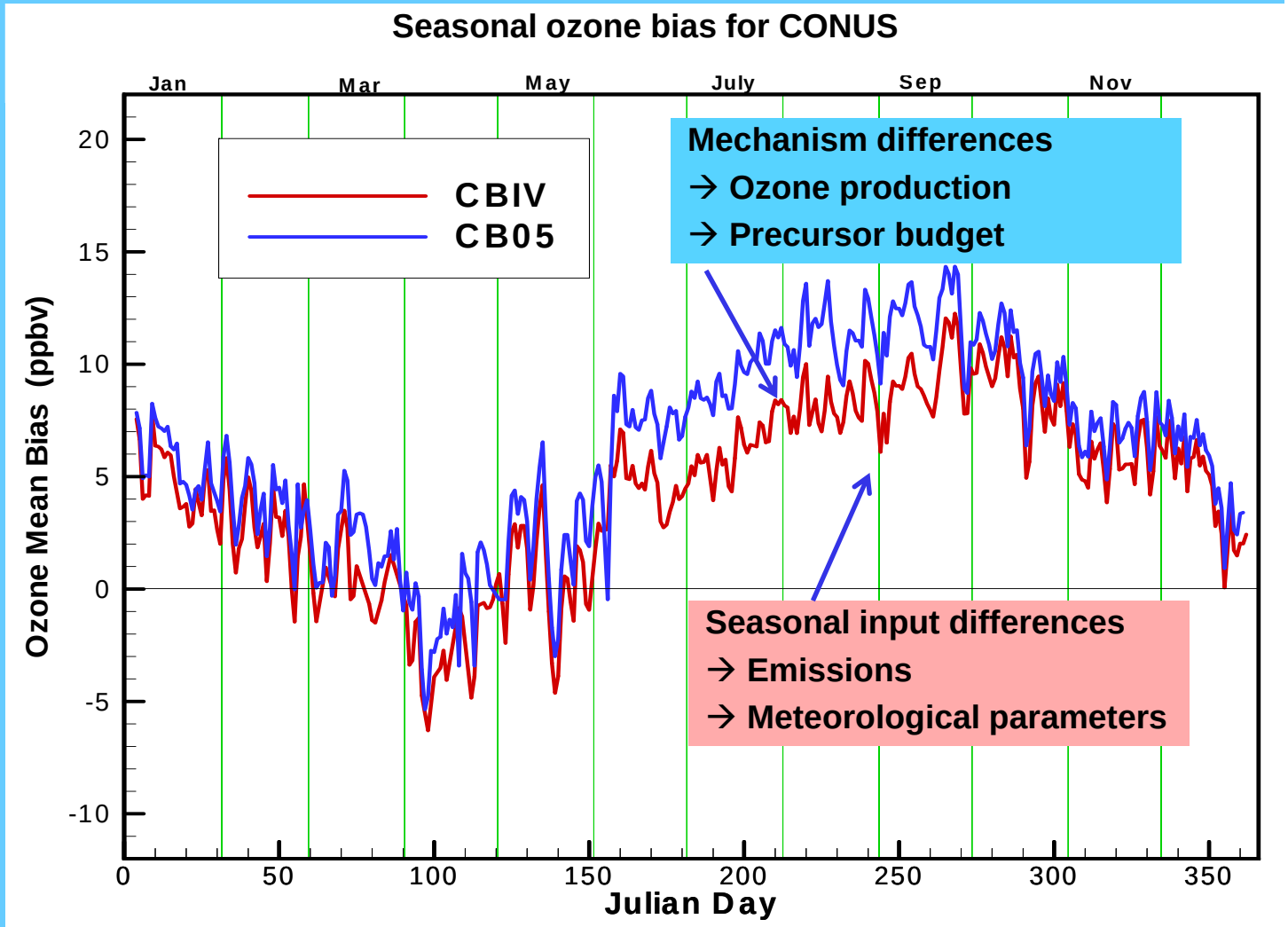
Chemical mechanism sensitivity analysis

Updated CB05 mechanism shows larger biases than CBIV

- Summertime,
- Eastern US.

Sensitivity studies in progress:

- Chemical speciation
- Indicator reactions



National Air Quality Forecast Capability
Looking Ahead

Nationwide ozone and particulate matter predictions

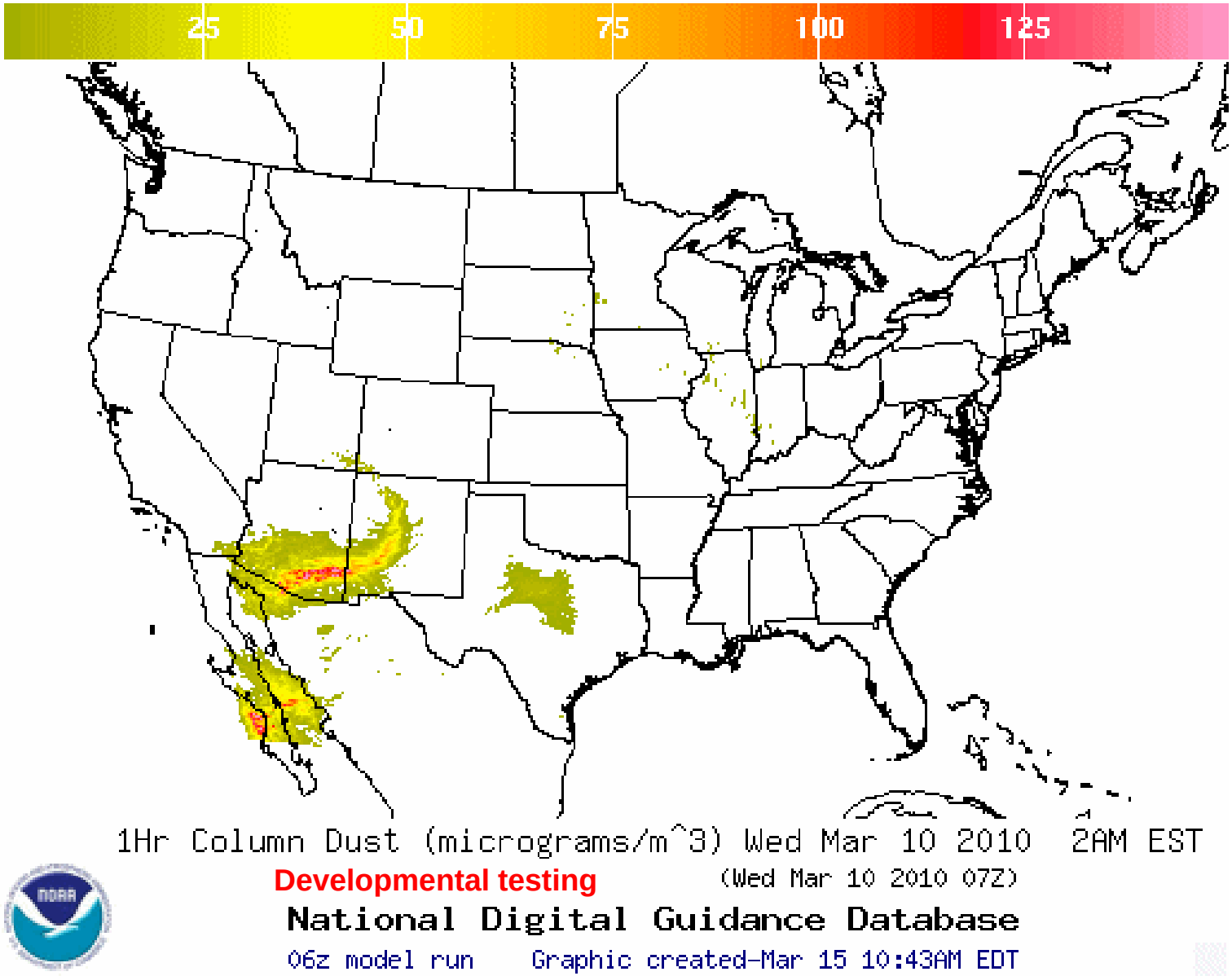
- ***Expanding ozone & smoke to 50-state coverage, Target: FY10***
- ***Dust implemented as separate module***
- ***Begin quantitative particulate matter predictions, Target: FY15***

•Providing information Nationwide on when/where poor AQ is expected

•Reducing losses to life (50,000) each year from poor AQ

•Reducing economic losses ($150B each year) from poor AQ

Testing of CONUS dust predictions



Program Overview, NAQFC:
Team Members

NOAA/NWS/OST	***Dr. Paula Davidson***	***NAQFC Manager***
NOAA/OAR	***Dr. Jim Meagher***	***NOAA AQ Matrix Manager***
NWS/OCWWS	***Jannie Ferrell***	***Outreach, Feedback***
NWS/OCIO	***Cindy Cromwell, Bob Bunge***	***Data Communications***
NWSOST/MDL	***Jerry Gorline, Marc Saccucci, Tim Boyer, Dave Ruth***	***Dev. Verification, NDGD Product Development***
NWS/OST	***Ken Carey, Dr. Ivanka Stajner***	***Program Support***
NESDIS/NCDC	***Alan Hall***	***Product Archiving***

NWS/NCEP

Jeff McQueen, Dr. Youhua Tang, Dr. Marina Tsidulko, Dr. Jianping Huang, Dr. Dongchul Kim	**AQF model interface development, testing, & integration**
***Dr. Sarah Lu , Dr. Ho-Chun Huang**	**Global data assimilation , feedback testing**
***Dr. Brad Ferrier, *Dan Johnson, *Eric Rogers, *Hui-Ya Chuang**	**WRF/NAM coordination**
Dr. Geoff Manikin	**Smoke Product testing and integration**
Dan Starostra,Chris Magee	**NCO transition and systems testing**
Robert Kelly, Mike Bodner, Andrew Orrison	**HPC coordination and AQF webdrawer**

NOAA/OAR/ARL

Dr. Daewon Byun, Dr. Pius Lee, Dr. Rick Saylor, Dr. Hsin-Mu Lin, Dr. Daniel Tong, Dr. Tianfeng Chai, Dr. Hyun-Chul Kim, Dr. Yunsoo Choi, *Dr. Fantine Ngan, Dr. Binyu Wang	**CMAQ development, adaptation of AQ simulations for AQF**
Roland Draxler, Glenn Rolph, Dr. Ariel Stein	**HYSPLIT adaptations**

NESDIS/STAR	***Dr. Shobha Kondragunta, Dr. Jian Zeng***	***Smoke Verification product development***
NESDID/OSDPD	***Matt Seybold, Mark Ruminski***	***HMS product integration with smoke forecast tool***

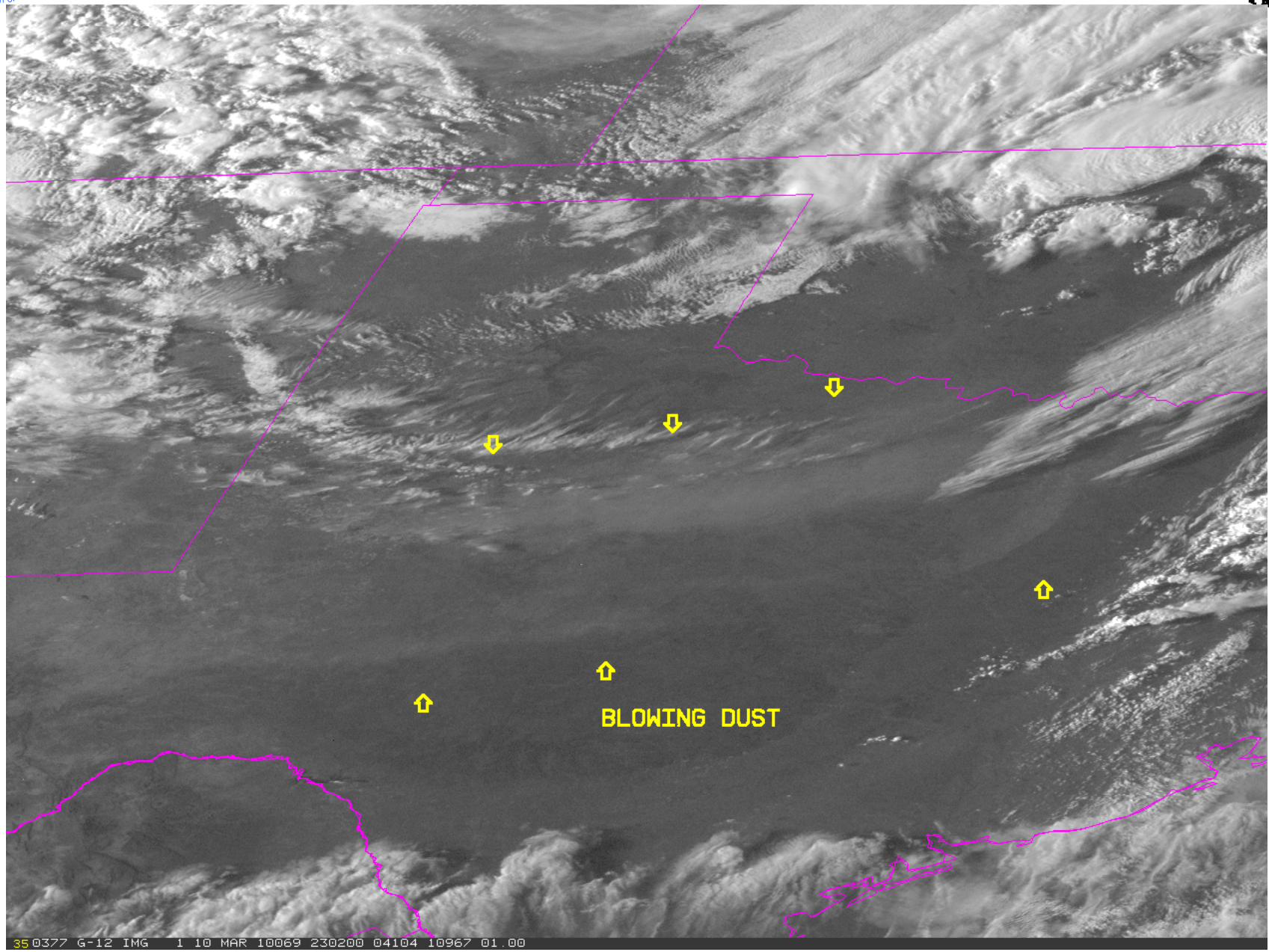
EPA/OAQPS partners:

Chet Wayland, Phil Dickerson, Scott Jackson, Brad Johns ***AIRNow development, coordination with NAQFC***

*** Guest Contributors**

Backup

GOES-12 image for March 10, 2010



Continuing Science Upgrades
Improvements to the expanding NAQFC

Continuing R&D required

- OAR and EPA working actively with NWS to provide prototype capabilities for pre-operational development, testing experimental production, and implementation

Assuring quality with science peer reviews:

- Design review of major system upgrades (initial, yearly upgrades)
- Diagnostic evaluations with field campaigns and evaluations
- Publication of T&E in peer-reviewed literature

Ozone Capability

- ***Otte et al. Weather and Forecasting, 20, 367-385 (2005)***
- ***Mckeen et al., J. Geophys. Res. 110, D21307 (2005)***
- ***Lee et al., J Applied Meteorology and Climatology (2007)***
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